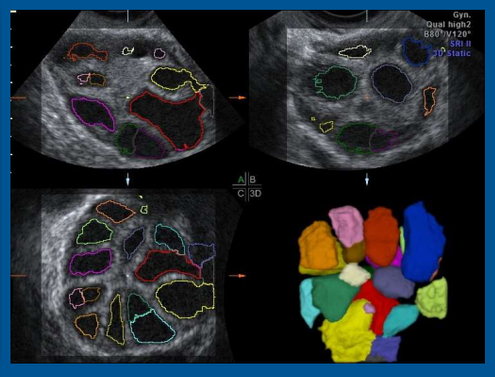
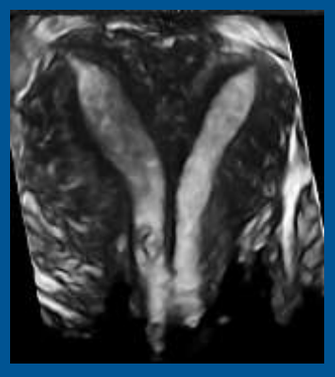
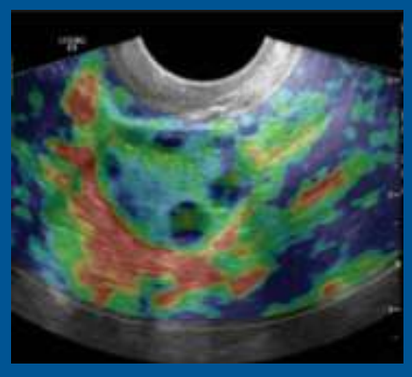





How Advanced Ultrasound Techniques Are Used in Assisted Conception

Angela Clough

Advanced Practice Sonographer

Derriford Hospital, Plymouth

BMUS AGM

12/12/24

Overview

Contrast imaging - HysteroContrastSonography–HyCoSy

- Saline infusion sonography - SIS

- Contrast-enhanced US - CEUS

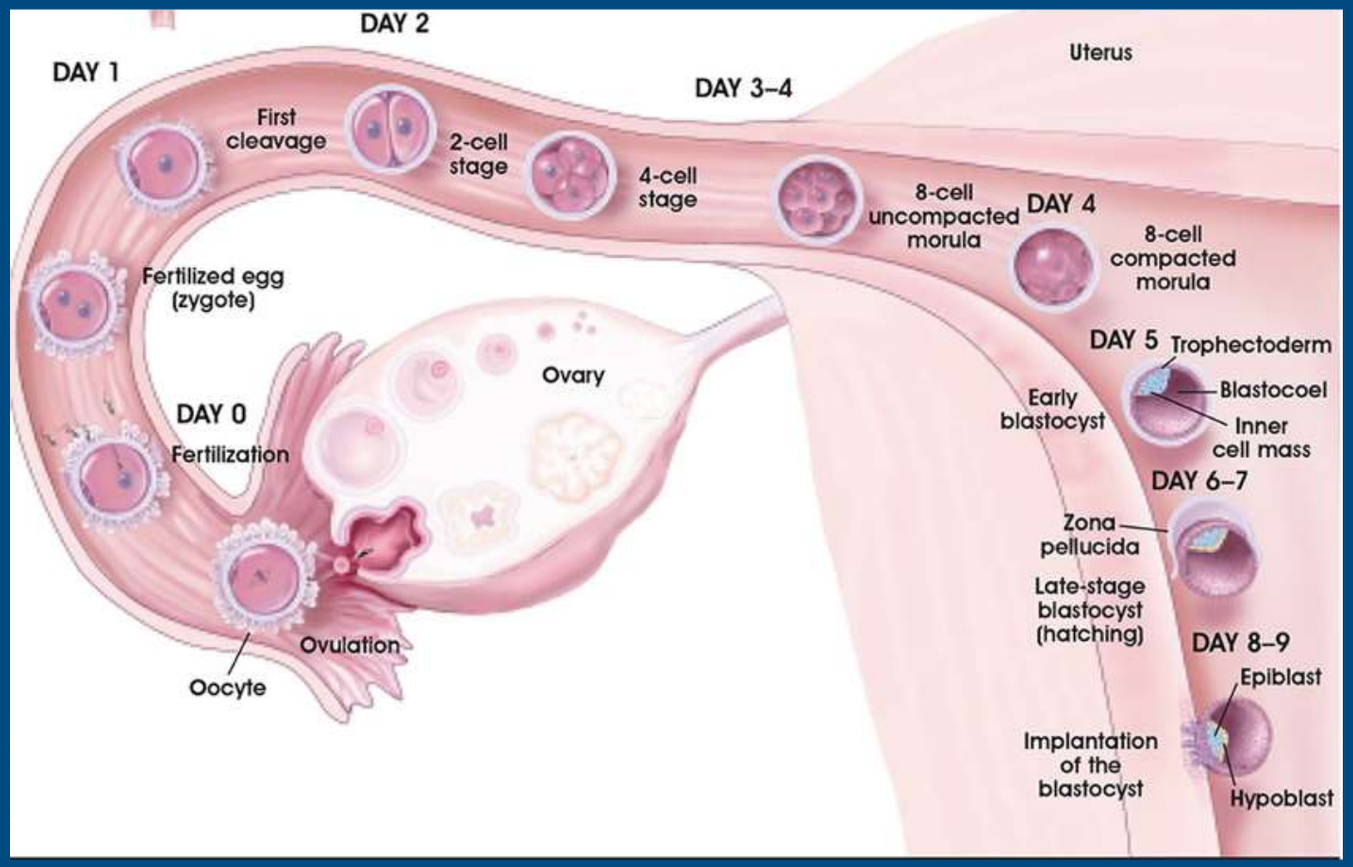
3D ultrasound

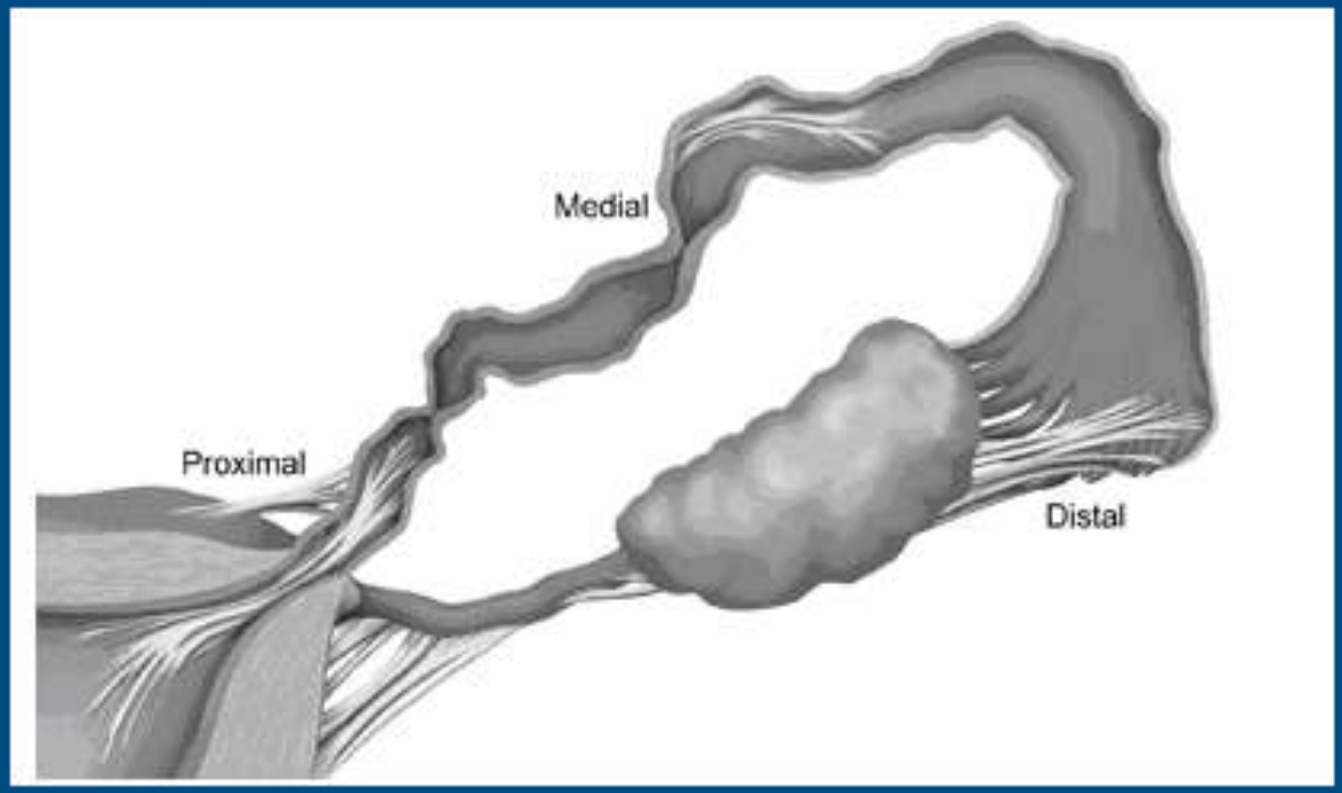
Elastography

Tubal factors in infertility

- Occlusion of tubes is the most common cause of infertility in women
- Accounts for 12% -33% of infertility overall
- 186 million people affected worldwide

Fallopian tube





Assessment of tubal patency

Screening

Diagnostic

Therapeutic

CAT	HyCoSY	HSG	Laparoscopy
History High titre Negative test	History To confirm normalcy Therapeutic?	More information Detect abnormality Therapeutic?	Detect/confirm Abnormality Therapeutic

No single test is suitable for all patients

Validation of HyCoSy

HyCoSy studies compared with reference study for the detection of tubal occlusion by study design.

	Study	Study design	Sample size	Study type	Reference standard	Sensitivity (%)	Specificity (%)	PPN (%)	NPV (%)	C (%)
1	Holz et al. (1997)	MA	1,007	HyCoSy	HSG	–	–	87.2	96.1	83.1
				HyCoSy	LSC	–	–	89.7	92.3	83.3
2	Campbell et al. (1994)	R	600	HyCoSy	HSG	–	–	–	–	84–91
				HyCoSy	LSC	–	–	–	–	80–93
3	Hamilton et al. (1998)	R	185	HyCoSy	LSC	90.4	70.3	91.2	68.2	85.8
4	Strandell et al. (1999)	P, B	103	HyCoSy	HSG	–	–	–	–	72.0
			43	HyCoSy	LSC	27.0	90.0	75.0	88.0	80.0
			43	HSG	LSC	73.0	87.0	47.0	94.0	83.0
5	Chenia et al. (1997)	P, B	50	HyCoSy	HSG	–	–	–	–	85.0
6	Radic et al. (2005)	P, B	68	HyCoSy	LSC	100.0	77.0	70.0	100.0	–
7	Mitri et al. (1991)	P, B	60	HyCoSy	HSG	–	–	–	–	72.0
8	Hamed et al. (2009)	P, B	57	HyCoSy	LSC	76.1	79.4	71.4	83.1	78.1
			57	HSG	LSC	81.8	77.1	69.2	87.1	79.9
9	Kiyokawa et al. (2000)[b]	P, B	25	HyCoSy	HSG	84.4[a]	100.0[a]	100.0[a]	33.0[a]	84.0
10	Deichert et al. (1989)	P	219	HyCoSy	LSC	83.7	87	63.2	87.0	86.3
			68	HyCoSy	HSG	80.6	85	65.9	92.4	83.8
			23	HSG	LSC	71.4	84.4	–	–	80.4
11	Deichert et al. (1987)	P	76	HyCoSy	HSG or LSC	100.0	90	–	–	87.5
12	Degenhardt et al. (1996)	P	57	HyCoSy	LSC	–	–	–	–	90.9
			20	HyCoSy	HSG	–	–	–	–	89.2
13	Tanawattanacharoen et al. (2000)	P	60	HyCoSy	LSC	–	–	–	–	80.0
14	Reis et al. (1988)	P	44	HyCoSy	LSC	85.2	85.2	71.9	92.9	85.2
			44	HSG	LSC	85.2	83.6	69.7	92.7	84.1
15	Inki et al. (1998)	P	32	HyCoSy	LSC	90.2[a]	83.3[a]	94.9[a]	71.4[a]	88.7
16	Exacoustos et al. (1996)	P	38	HyCoSy	HSG	80.0	94.0	84.0	92.0	89.6
			15	HyCoSy	LSC	75	91	75	91	86.7
			15	HSG	LSC	88	86	70	95	86.7
17	Volpi et al. (2003)	P	29	HyCoSy	LSC	80.0	85.0	85.0	80.0	82.7
			10	HyCoSy	HSG	–	–	–	–	100.0
18	Dietrich et al. (1996)	P	20	HyCoSy	LSC	–	–	–	–	82.5

Conclusion(s)

Increasing evidence supports the more recently described hysterosalpingo-contrast sonography procedure as an acceptable screening study for the subfertile patient with the potential advantage that it is a comprehensive evaluation, methodologically simple, cost effective, and time efficient.

Saunders. Tubal patency assessment. Fertil Steril 2011

NICE recommendations

1.3.8 Investigation of suspected tubal and uterine abnormalities

1.3.8.2 Where appropriate expertise is available, screening for tubal occlusion using hysterosalpingo-contrast-ultrasonography should be considered because it is an effective alternative to hysterosalpingography for women who are not known to have comorbidities. [2004]

Advantages and limitations of HyCoSy

Simple, convenient

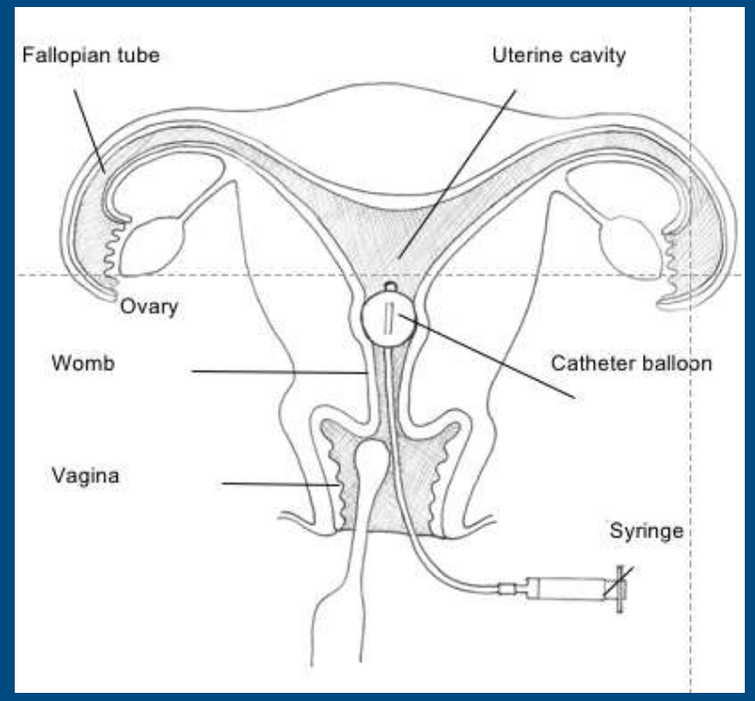
Well tolerated

Good uterine and adnexal assessment

May be therapeutic (flushing and/or immune response?)

Limited detail of endosalpinx

No current corrective treatment



HyCoSy video

Saline infusion sonography

‘Aqua Scan’

‘Sonohysterography’

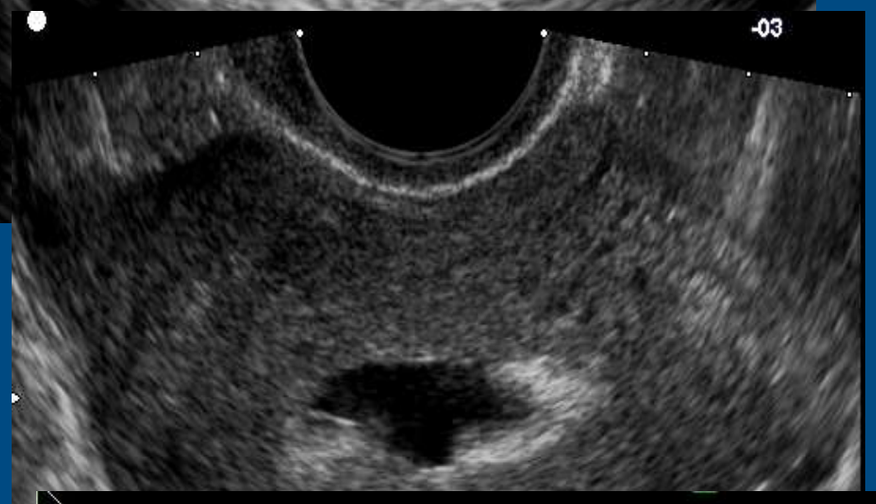
‘Hysterosonography’

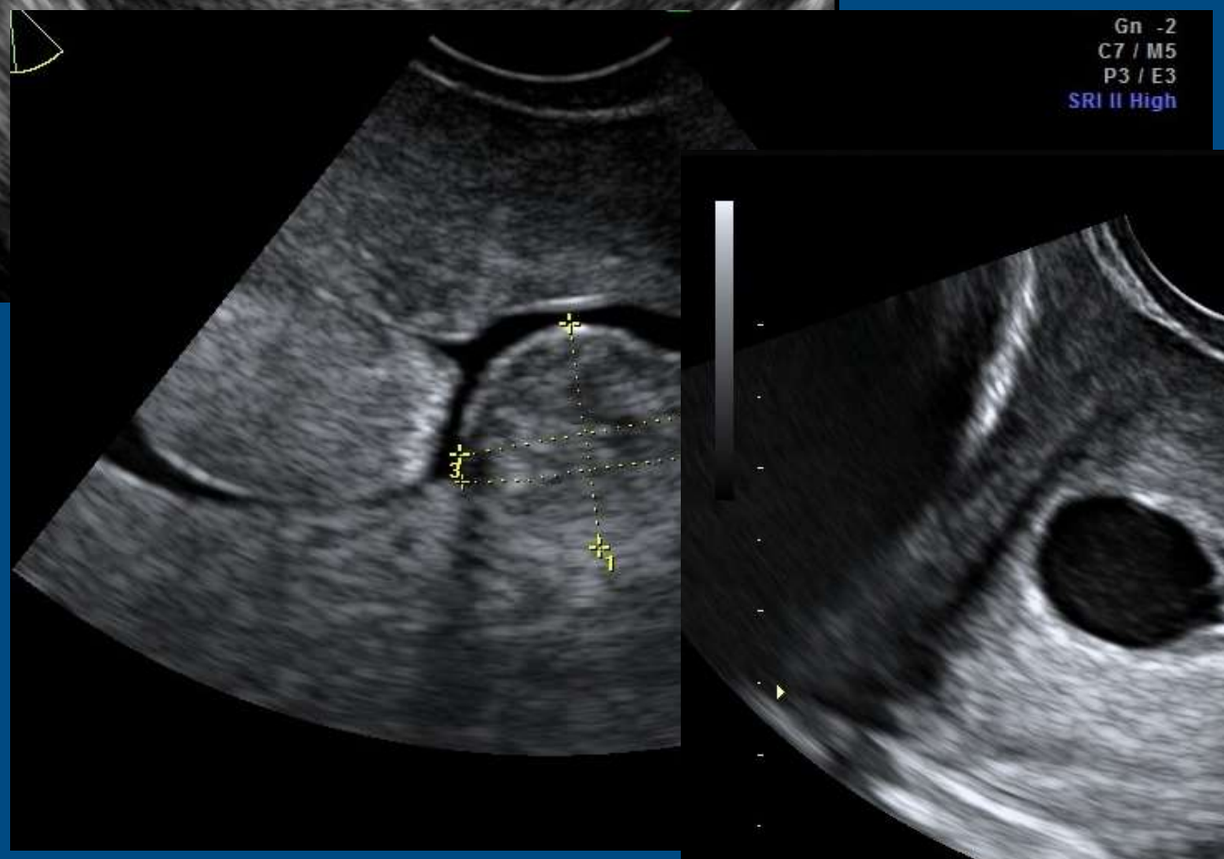
Instillation of saline into the uterine cavity under real-time ultrasound- saline is anechoic and sometimes called a ‘negative contrast’

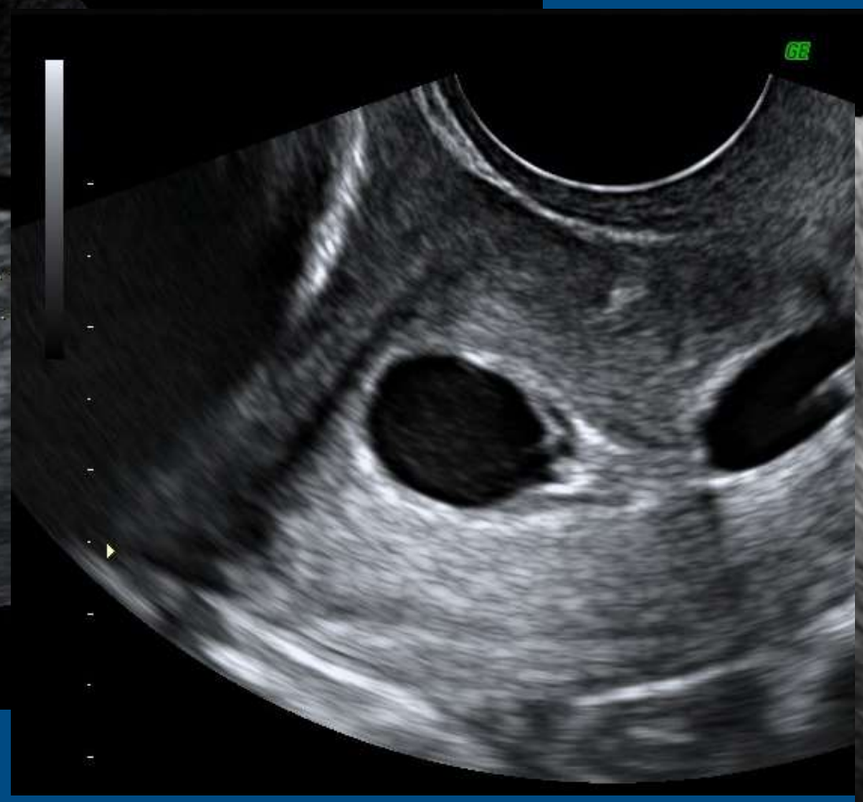
Uterine cavity malformations have a prevalence of 11-40% in infertile population

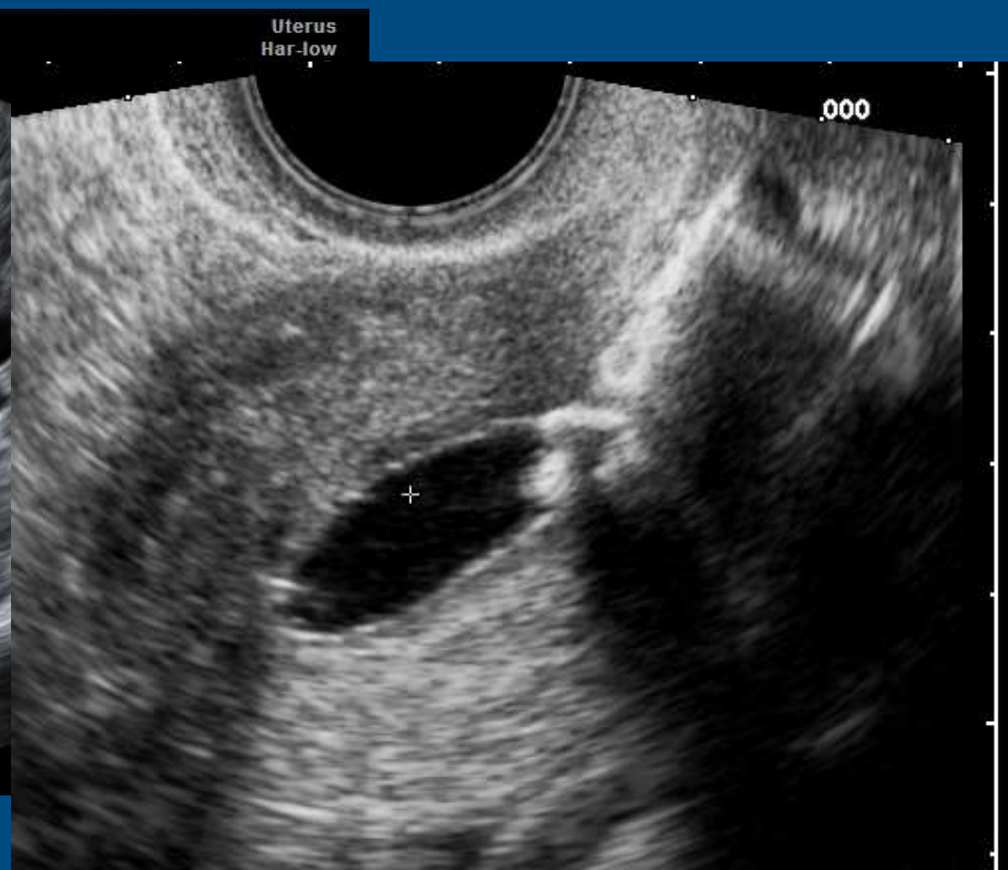
Saline infusion sonography video

Pathology detected with Saline Infusion Sonography









Contrast-enhanced ultrasound (CEUS)

-Microvascular imaging shows differential perfusion between pathological lesions and healthy tissues - observing ‘type’ and ‘timing’ of perfusion

- Well established for assessing upper abdominal organs and to a degree in small parts ultrasound

Fibroid

Arterial phase

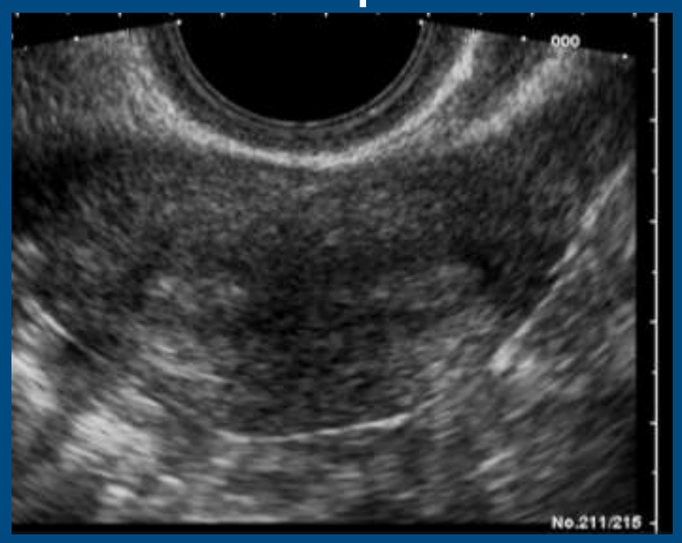
Delayed phase

Adenomyosis

Role of 3D ultrasound in the infertile patient

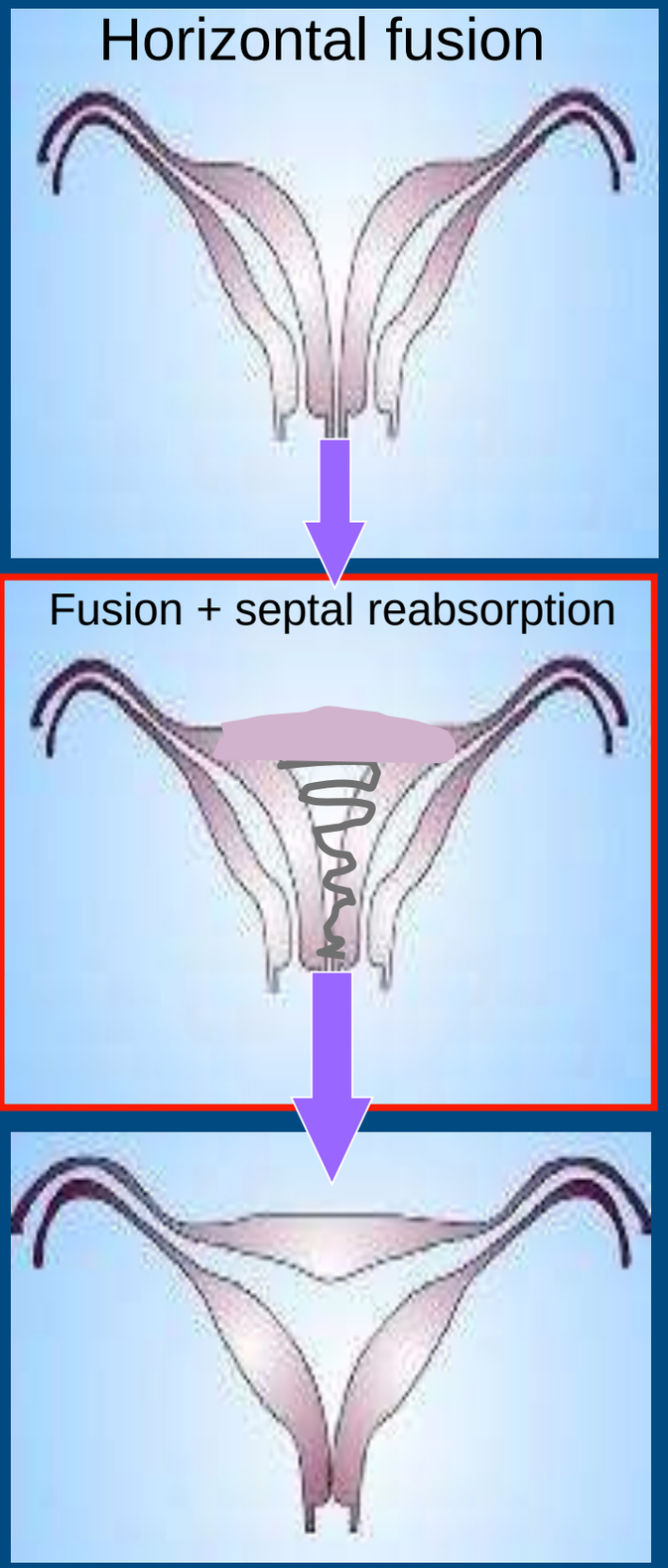
Longitudinal plane

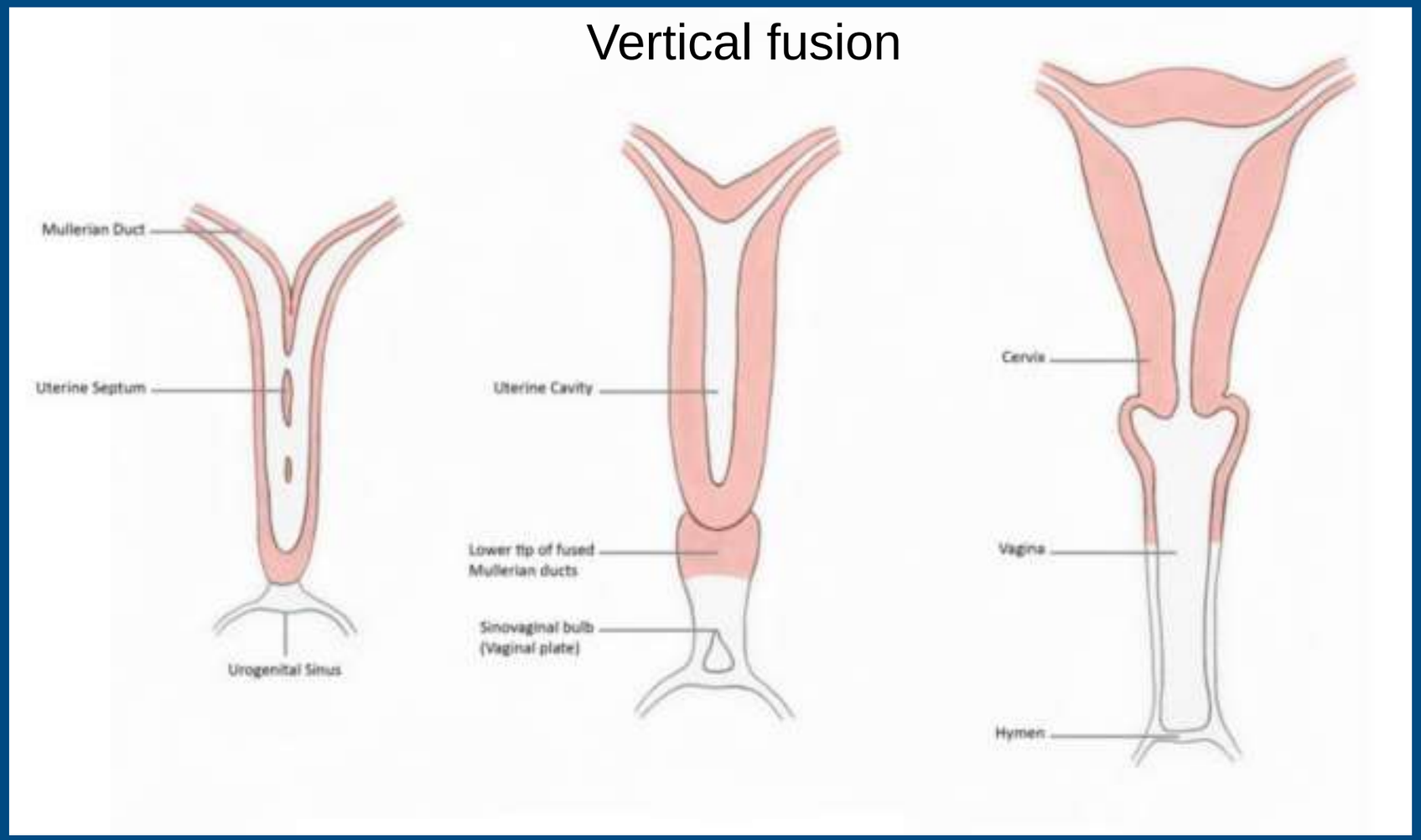
Transverse plane



Coronal plane

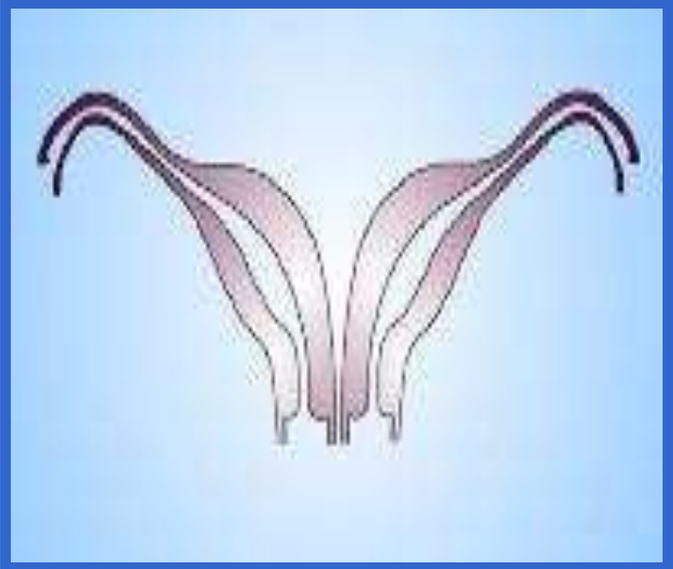
Mullerian duct development

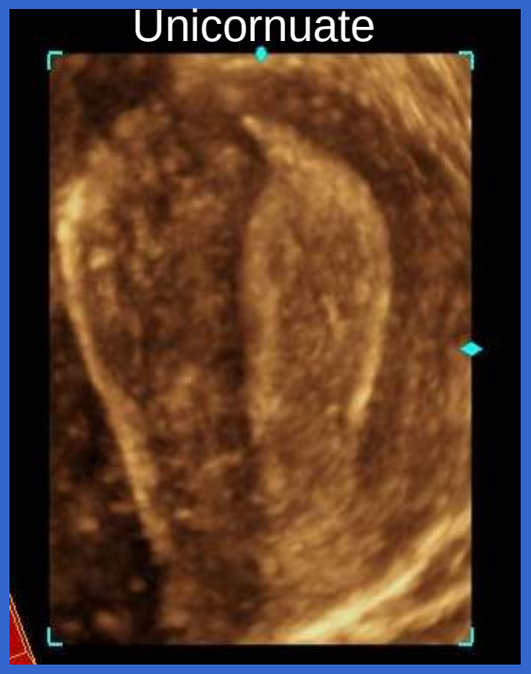


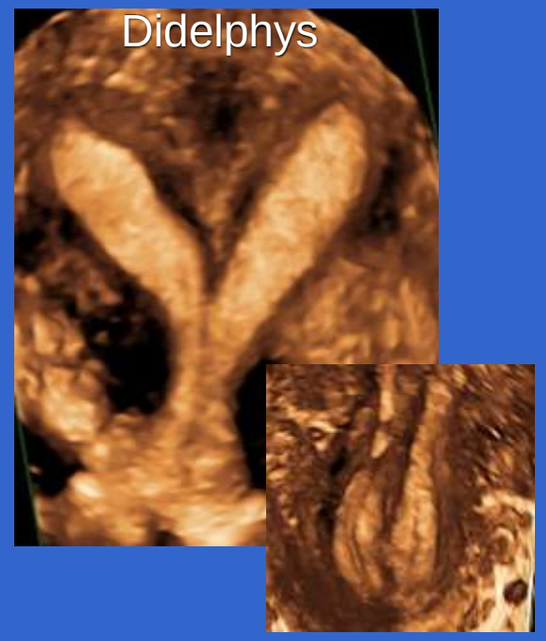


Horizonal fusion uterine malformations

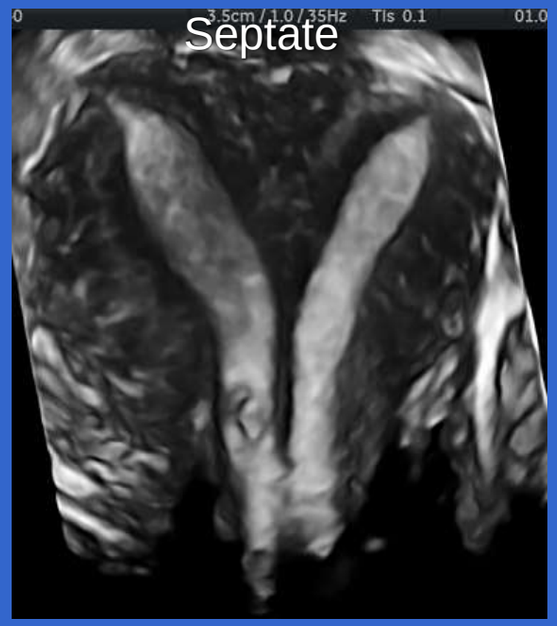
Bicorporeal



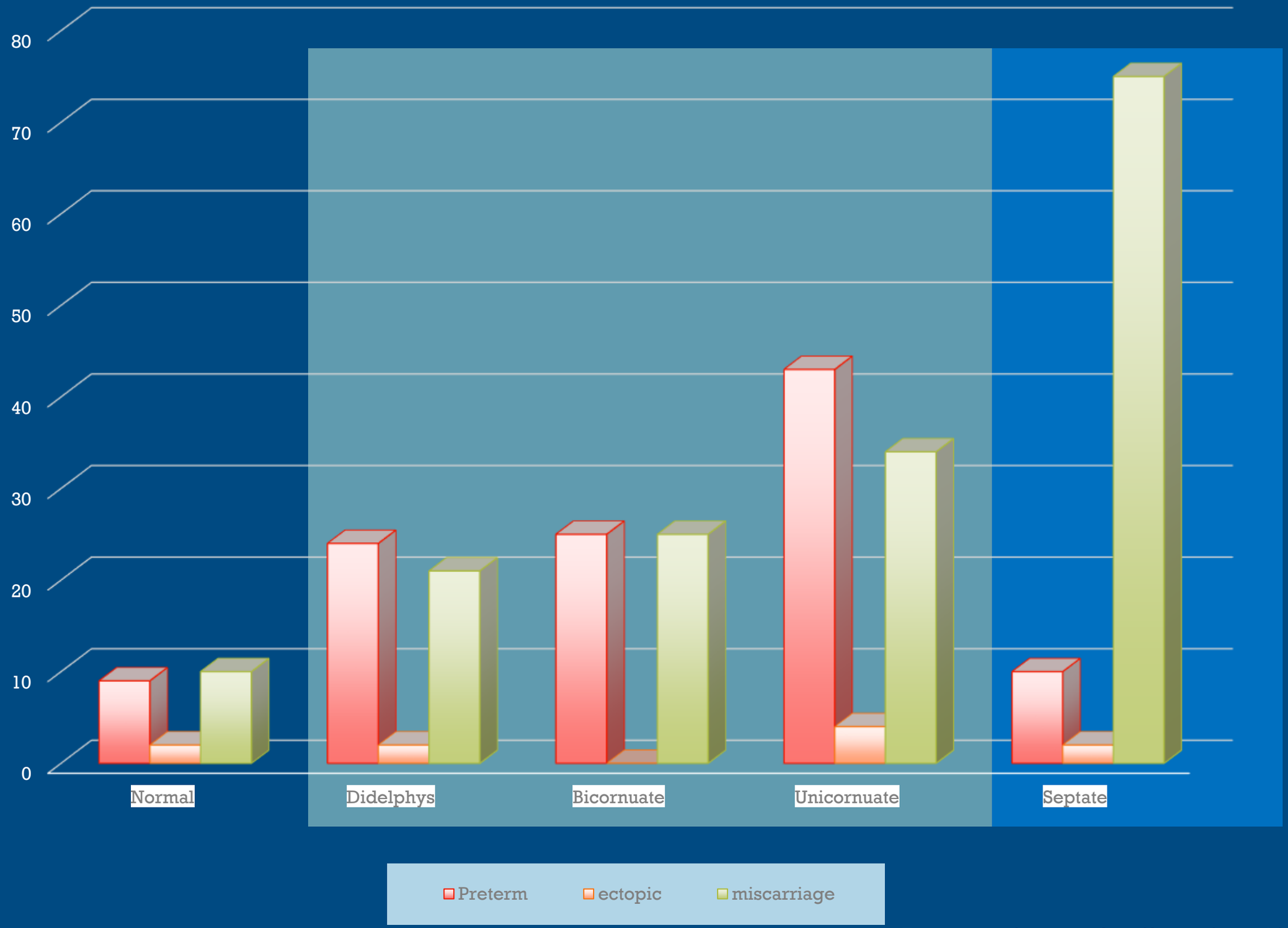




Unicorporeal



Pregnancy impact of bicorporeal and unicorporeal uterine malformations



Pregnancy impact of malformations: Liebert, 2004

Obstetric implications of uterine malformations

1st trimester

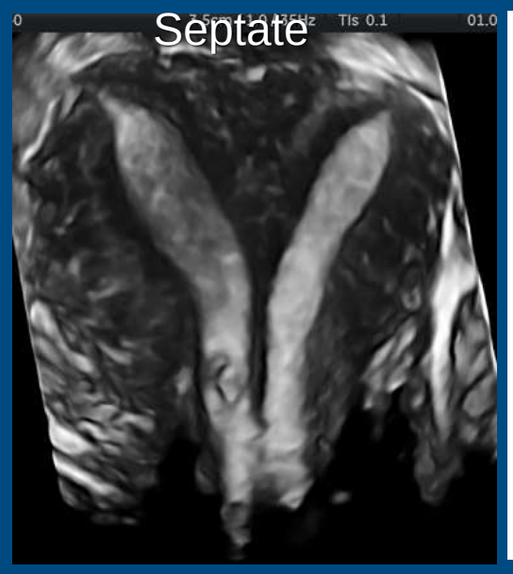
Septal myometrium and endometrium may not adequately support developing embryo

2nd + 3rd Trimester

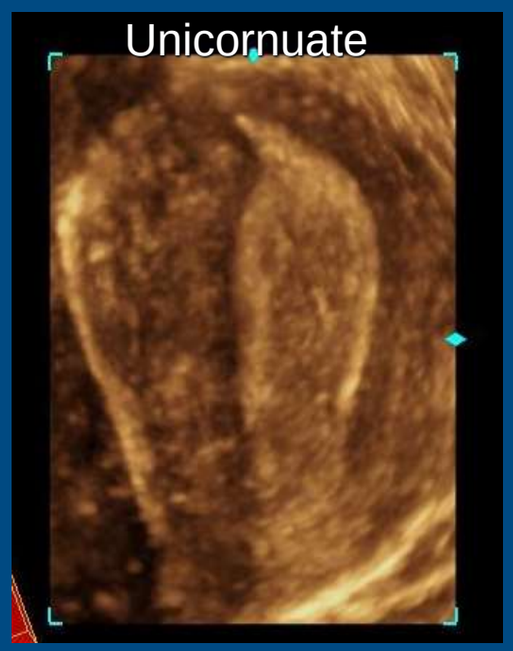
Abnormal uterine – volume
- vasculature
- muscle mass
- contractility

Cervical incompetence/abnormality

Unicorporeal malformation



Bicorporeal malformations



Classification systems of Mullerian Duct abnormalities

1988
American Fertility Society (AFS)

Class I – Uterine /Cx agenesis

Class II – Unicornuate uterus

Class III – Didelphys uterus

Class IV – Bicornuate uterus

Class V – Septate uterus

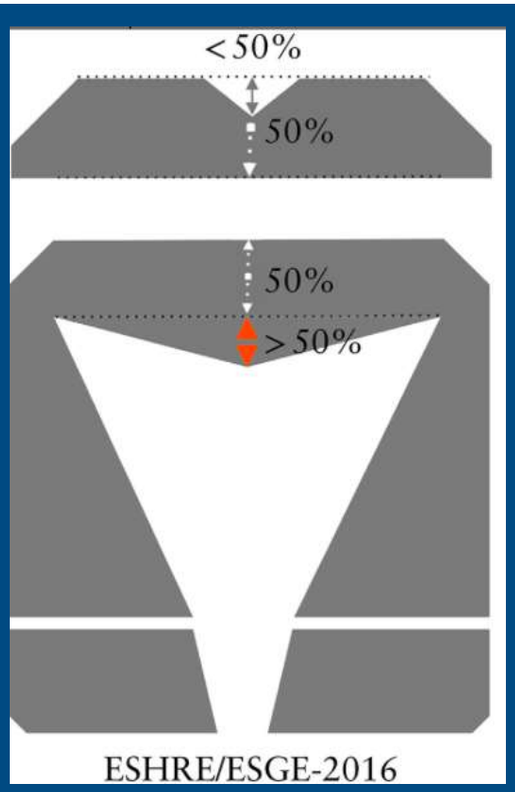
Class VI – Arcuate uterus

Class VII – DES exposure

2013
European Society of Human Reproduction & Embryology (ESHRE)

ESHRE/ESGE classification
Female genital tract anomalies

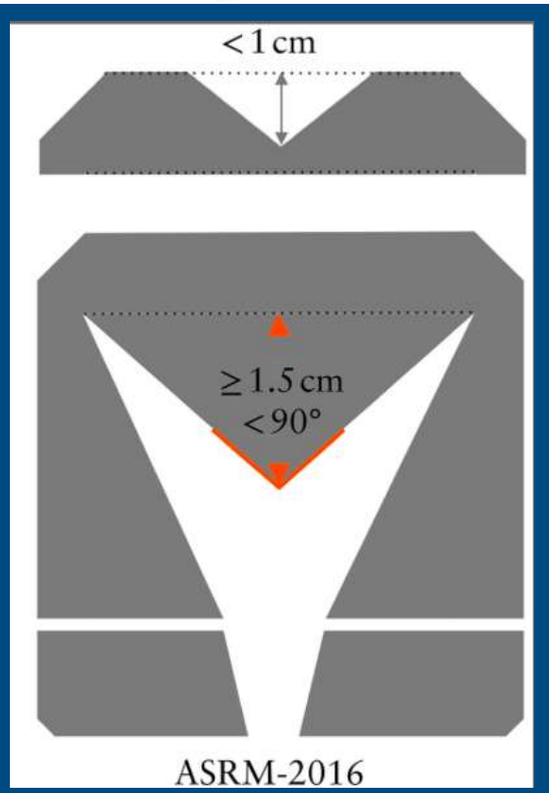
	Uterine anomaly		Cervical/vaginal anomaly	
	Main class	*Sub-class*	*Co-existent class*	
U0	Normal uterus		C0	*Normal cervix*
U1	Dysmorphic uterus	**a.** T-shaped **b.** Infantilis **c.** Others	C1	*Septate cervix*
U2	Septate uterus	**a.** Partial **b.** Complete	C2	*Double 'normal' cervix*
U3	Bicorporeal uterus	**a.** Partial **b.** Complete **c.** Bicorporeal septate	C3	*Unilateral cervical aplasia*
U4	Hemi-uterus	**a.** With rudimentary cavity (communicating or not horn) **b.** Without rudimentary cavity (horn without cavity/no horn)	C4	*Cervical aplasia*
U5	Aplastic	**a.** With rudimentary cavity (bi- or unilateral horn) **b.** Without rudimentary cavity (bi- or unilateral uterine remnants/aplasia)	V0	*Normal vagina*
			V1	*Longitudinal non-obstructing vaginal septum*
			V2	*Longitudinal obstructing vaginal septum*
			V3	*Transverse vaginal septum and/or imperforate hymen*
			V4	*Vaginal aplasia*
U6	Unclassified malformations			
U			*C*	*V*



2016 / 2021
American Society for Reproductive medicine (ASRM)

Table 3. ASRM Mullerian anomalies' classification 2021 [7].

Main Category	Subcategories
Mullerian agenesis	- Complete Müllerian agenesis - Müllerian agenesis with R/L atrophic uterine remnant with functional endometrium
Cervical agenesis	- Complete Cervical agenesis
	- Distal Cervical agenesis
Unicornuate uterus	- R/L Unicornuate uterus - R/L Unicornuate with R/L distal atrophic uterine remnant - R/L Unicornuate with R/L distal uterine remnant with functional endometrium - R/L Unicornuate with R/L associated atrophic uterine remnant - R/L Unicornuate with R/L uterine horn communicating at level of cervix
Uterus Didelphys	- Uterus didelphys and complete longitudinal vaginal septum - Uterus didelphys and +/– longitudinal vaginal septum of variable length - Uterus didelphys and obstructed R/L hemi vagina
Bicornuate uterus	- Bicornuate uterus (with single cervix) - Bicornuate uterus with R/L communicating tract - Uterus bicornuate bicollis - Combined bicornuate septate uterus
Septate uterus	- Partial septate uterus - Normal/arcuate uterus - Robert's uterus (Septate uterus with non-communicating hemi uterus) - Complete septate uterus with duplicated cervices and longitudinal vaginal septum - Complete septate uterus with septate cervix and longitudinal vaginal septum - Complete septate uterus, duplicated cervices, and obstructed R/L hemi vagina
Transverse vaginal septum	- Midvaginal septum - Distal vaginal agenesis
Longitudinal vaginal septum	- Longitudinal vaginal septum of variable length - Longitudinal vaginal septum of variable length and uterus didelphys - Longitudinal vaginal septum of variable length and complete septate uterus with duplicated cervix - Obstructed R/L hemi vagina and uterus didelphys - Obstructed R/L hemi vagina and complete septate uterus with duplicated cervices
Complex anomalies	- Bicornuate uterus with bilateral obstructed endometrial cavities - Uterus didelphys with communicating hemi uteri and unilateral R/L cervico-vaginal atresia - Obstructed R/L hemi vagina, hemi uterus and single cervix with separate contralateral R/L patent hemi uterus, cervix and vagina - Bicornuate uterus with R/L communicating tract and transverse vaginal septum - Uterus isthmus agenesis



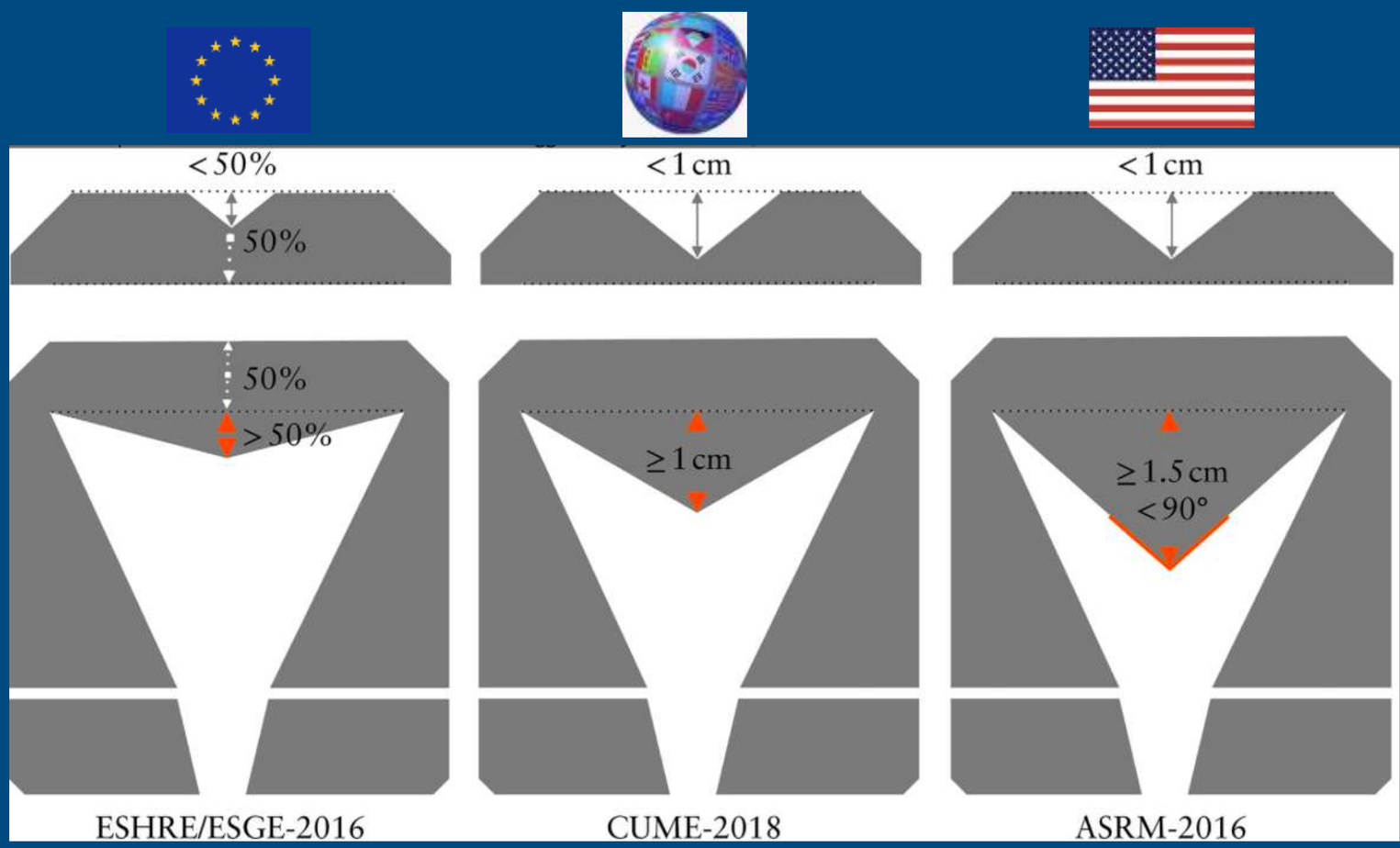
Congenital Uterine Malformation by Experts (CUME): Better criteria for distinguishing between normal/arcuate and septate uterus?

Proposed modification of prior recommendations -

- Septal length >10mm
- Septal angle <140º and
- Indentation-wall thickness ratio of >110%

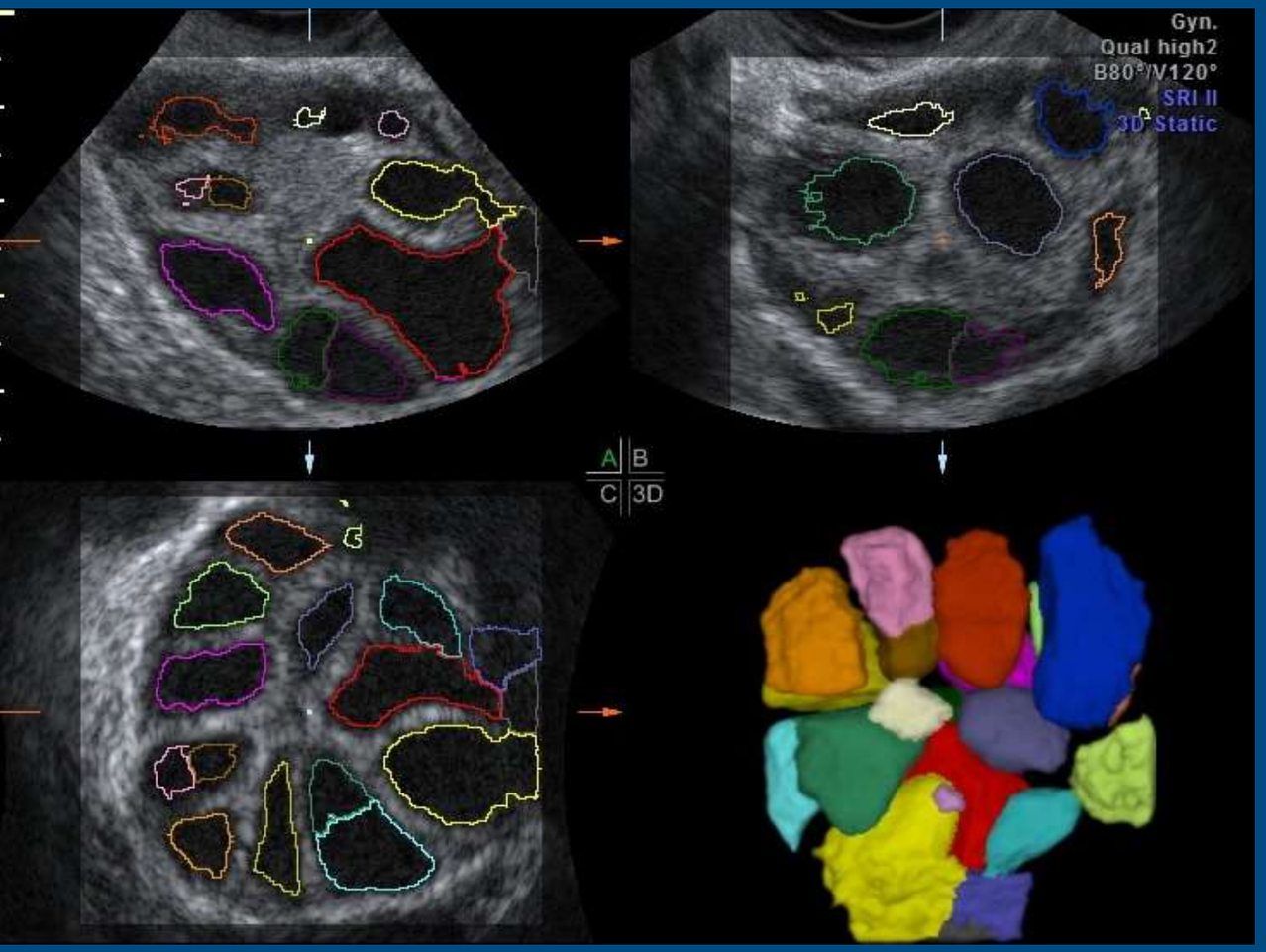
Or

- *use septal indention of >10mm alone as the simplest most reproducible criteria.*



A Ludwin er al. Ultrasound Obstet Gynecol. 2018 Jan

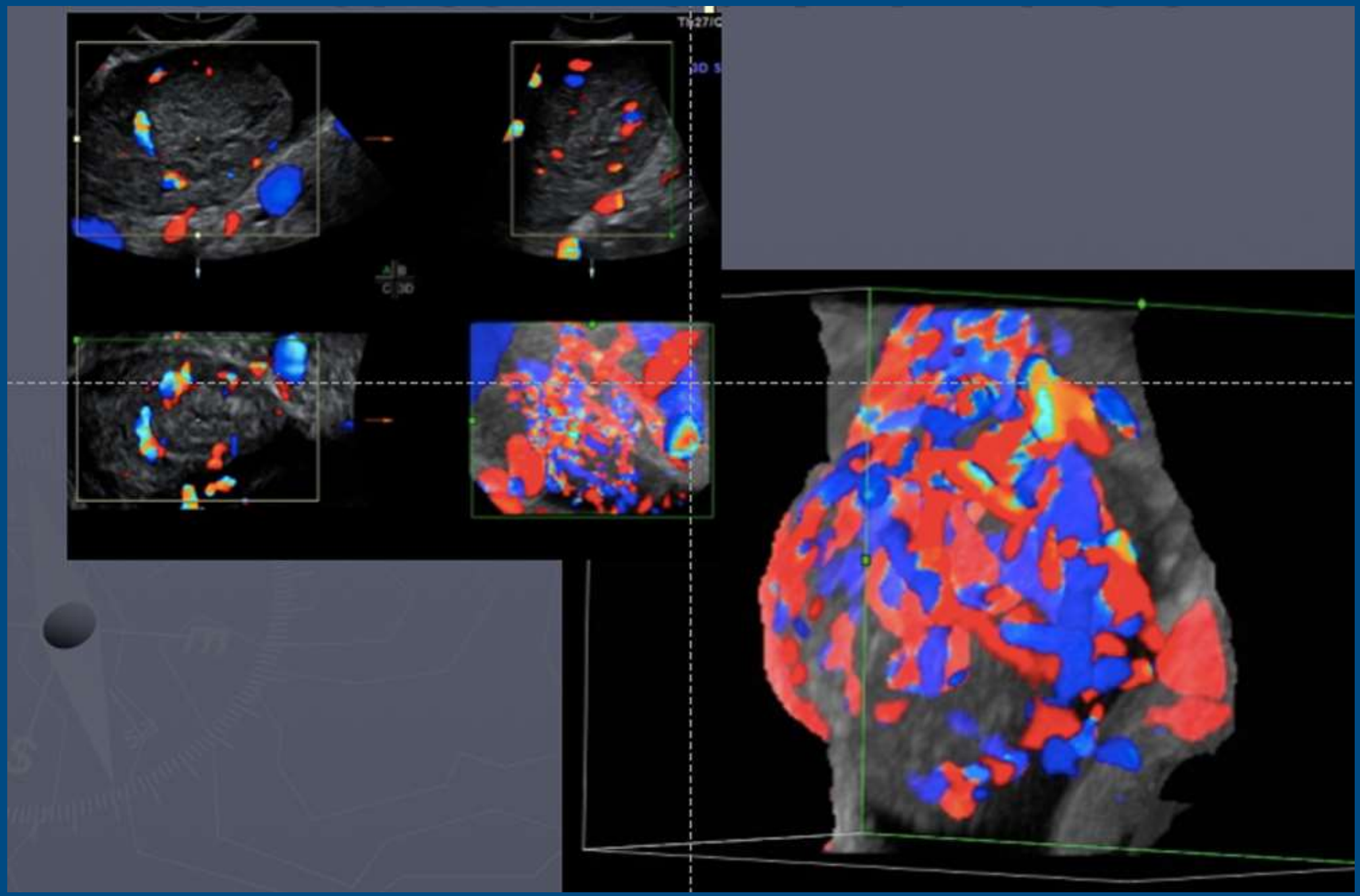
3D assessment of superovulated ovaries



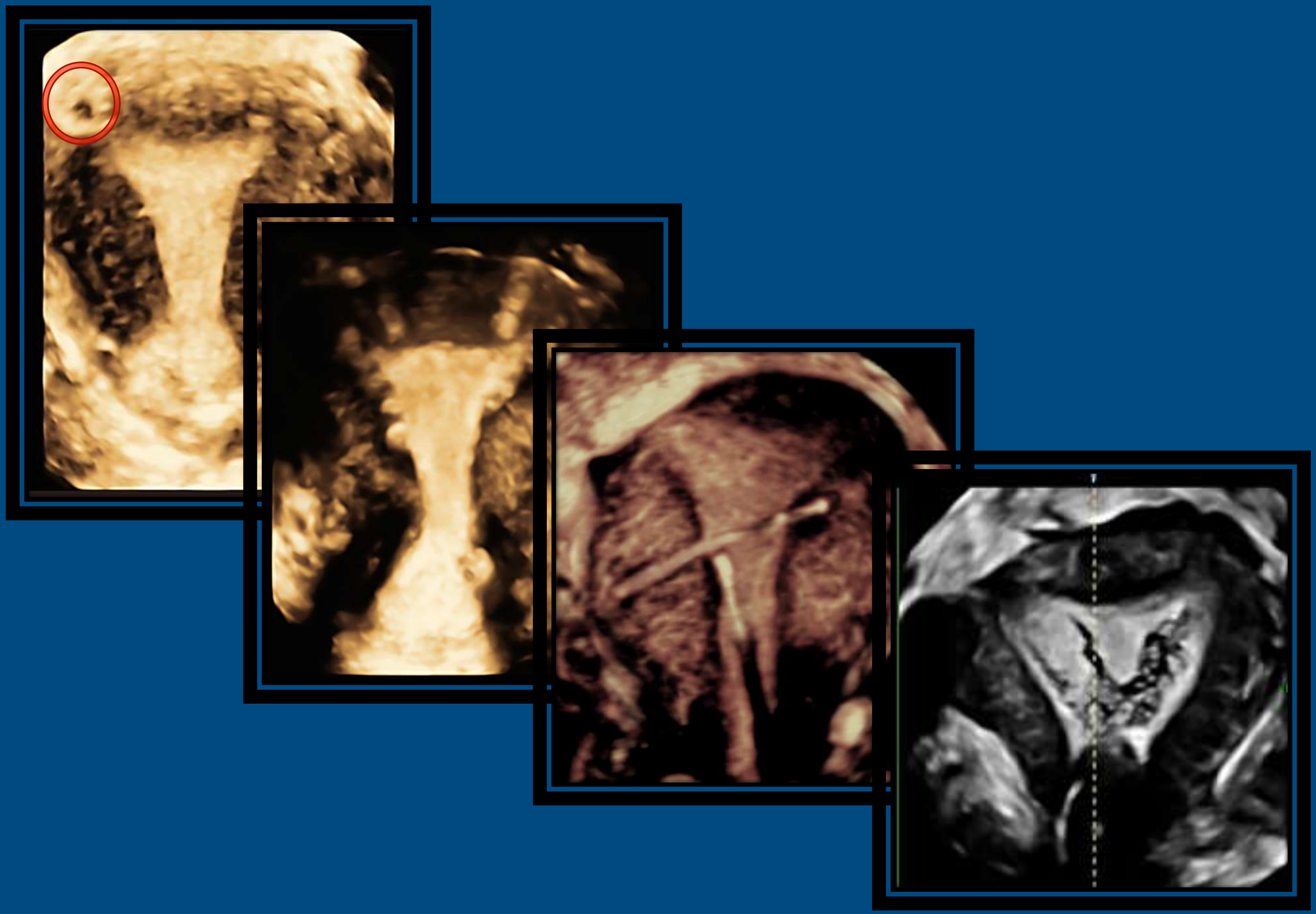
Ovary:	Left					
Total#:	22					
Nr.	d(V) mm	dx mm	dy mm	dz mm	mn. d mm	V cm³
14	8.5	12.5	8.8	6.5	9.3	0.32
15	8.4	12.9	10.1	4.8	9.3	0.31
16	7.2	9.4	8.3	5.2	7.6	0.19
17	6.3	9.3	6.2	5.1	6.8	0.13
18	6.2	9.1	6.5	5.4	7.0	0.13
19	6.1	7.9	6.1	5.3	6.4	0.12
20	4.7	6.4	5.1	3.4	5.0	0.05
21	1.9	2.2	2.0	1.9	2.0	<0.01
22	1.6	1.8	1.8	1.5	1.7	<0.01

Ovary:	Right					
Total#:	25					
Nr.	d(V) mm	dx mm	dy mm	dz mm	mn. d mm	V cm³
14	9.3	12.3	11.0	7.2	10.2	0.43
15	9.0	15.8	7.4	6.9	10.1	0.38
16	8.2	10.5	9.7	6.1	8.8	0.28
17	8.1	14.3	7.9	5.4	9.2	0.28
18	7.7	11.7	7.5	5.6	8.3	0.24
19	7.7	10.7	7.7	6.1	8.2	0.24
20	7.4	9.1	7.8	6.4	7.8	0.21
21	5.3	6.9	5.3	4.3	5.5	0.08
22	5.2	6.7	5.2	4.6	5.5	0.07
23	5.1	6.8	5.1	4.4	5.4	0.07
24	4.4	6.2	4.4	3.6	4.7	0.04
25	2.6	3.6	3.1	2.2	2.9	<0.01

3D colour map of a fibroid

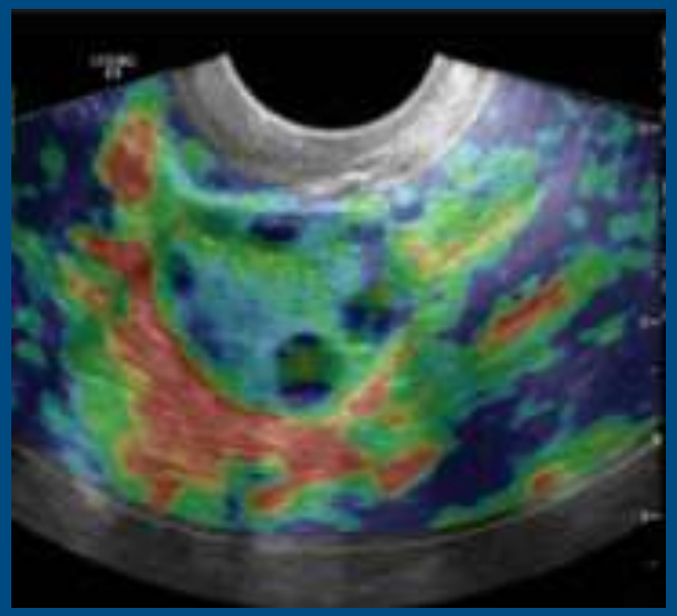


Other advantages of 3D



Elastography

Elastography (SWE) used to measure stiffness of tissue



- Stiffness is age related change in ovary due to inflammation and fibrosis
- Elastography can effectively act as a ‘biomarker’ for ovarian fibrosis
- Fibroisis particularly associated with PCOM and ovarian cancer
- Uterus - Fibroids and adenomyosis stiffer that normal myometrium

Elastography
Active areas of research

Fibroids and adenomyosis – elastography can aid diagnosis and assess potential therapies

PCOS – have increased fibrosis - monitoring may provide -early diagnostic tool,
-monitor disease progression
-efficacy of treatment

Endometriosis - Ovarian stroma adjacent to endometriomas significantly stiffer than in an ovary with a haemorrhagic cyst

Cervical incompetence- elastography can assess for premature softening of the cervix providing a potential biomarker for assessing preterm labour

Conclusion

- Advanced techniques in ultrasound are highly advantageous for assessing the infertile patient

- HyCoSy, SIS and 3D ultrasound are well established techniques

- Use of vascular contrast agents and elastography have potential but are not currently used in routine assessment

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